

PHILOSOPHICAL TRANSACTIONS.

June 10, 1683.

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An Abstract of a Letter from Mr. Anthony Leewenhoeck of Delft to Mr. R. H. concerning the appearances of several Woods, and their Vessels.

The Preface to the Letter.

I am not ignorant that the present subject has been learnedly treated of, by the judicious *Malpighius* and Dr.
 D d N. Grew

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N. Grew; I have ventured notwithstanding to represent the Vessels in Wood after such manner as they offer'd themselves to me. *B. C. D. Fig. 1.* is a part of the circumference of an Oak or Ash Tree &c. being of 18 years growth and therefore having 18 Rings for every year one, that which is made the last year being alwayes the greatest, tho not alwaies proportionably great, but according as the year is more or less fruitful.

^a The pieces described in my following Figures are such as * *E* in the 15th Ring, and sometimes not so big: yet from such a part I doubt not but the Constitution of the whole Tree may sufficiently be understood.

When a Tree is sawed a-cross, and afterwards plained very smooth, we^b see lines as it were drawn from the Center *A.* and reaching to the Circūmference *B.* these are Vessels which carry the Sap to the Bark; as by the adjoynd Figures will appear.

The LETTER.

MY last to you was of the 20th of November, wherein I acquainted you of my thoughts of the Stone, Gravel, and Gout; which I hope you have received. You recommend to me in yours of the 17th of October, to examin fruitful and unfruitful Eggs. I have examined the Spots of several Eggs, but have found nothing notable therein. I will endeavour to know whether the Egg be fruitful before I examin it.

^a The same noted by *Dr. Grew Anatomy of Trunks p. 24.*

* Note the Figures as they are here graved are not so big as those designed by the Author being sometimes but $\frac{1}{2}$ (or other part) of their length, and so must be supposed not to reach from Ring to Ring as *E.*

^b The same which *Dr. Grew* calls the Insertions, *Anatomy of Plants begun, Chap. 2. And Diametral Rays, Anatomy of Tr. p. 20, 30, &c.*

The Grasshoppers hereabout are small and few, about the length of the Nail of ones hand : possibly in your Country they are more and greater.

We are very shy here of cutting open bodies, even of those that are dead in the Hospital : so that I have no opportunity of knowing whether the Chalky matter be in the Veins or no.

I send you herewith some Observations of Wood. Fig. 2. A B C D shews a piece of Oak, which observed in a Microscope was thus drawn from a piece of Wood as big as H.

F F: F F where the brown stroaks appear, are the Separations of the growth of one year. For when the growth doth stop, the Wood becomes firm, and thick ; and is supplied with many small Vessels, such as are hardly to be distinguished, and therefore appear as brown Rays or streaks. between the said F F. F F is comprehended that thickness of Wood which has been added to the Circumference of a Tree by a years growth. The Wood hath five sorts of Vessels, viz. Three sorts going upwards, two lying Horizontally. E E E denote large ascending Vessels made every year in the Wood in the Spring, when it begins to grow. These are filled within with small Bladders, which have very thin Skins, here expressed in one of the greater Vessels, cut long ways in the third Figure by I K L M.]

The second sort of rising Vessels are much smaller, which also are made of very thin Skins, and are also speck't with parts which by a common Microscope appear like Globules, as Fig. 4. O N where one of the said Vessels is cut long ways.

c See a Figure of the same wood with all the same five parts, in Dr. Grew's *Anat. of Plants* begun. And the Partitions of the Great Horizontal Parts, hereafter mentioned, see in his *Anat. of Roots*, Tab. 7.

The third sort of rising Vessels are very small and in great number, being made also of very thin Skins, as Fig. 4. P Q where they are drawn longways.

All these ascending Vessels in the aforesaid piece of Wood, which is about $\frac{1}{16}$ of a Square Inch, are I guess about 20000 Vessels. Hence in an Oak Tree of four foot Diameter are 3200 Millions of ascending Vessels, and in one of 1 foot, there are 200 Millions of Vessels. If we suppose 10 of these great and small Vessels in a day to carry up 1 drop of Water, and that 100 of these drops make one Cubick Inch, there will be 200000 Cubick Inches. These Inches reduced to feet, amount to full 115 Cubick feet of *Rhinland* measure, of 12 Inches to the foot; and one Cubick foot weighing 65 lib. of our *Delph* water, the whole will amount to 7475 lib. or 14 Bordeaux Hogsheads of water, which a Tree of one foot Diameter in one day can bring up. Whereby it appears, that how small soever the Quantity of water is which a Pipe or Vessel may be supposed to carry up, yet if all the Vessels were employed to that use, how much the Total would amount to. But I conceive that several of these Vessels convey of the same moisture downwards again to the Root, and so cause a Circulation: as I have formerly said.

These forementioned uprising Vessels empty constantly their Sap into an incredible number of Vessels, which lye Horizontally in the body of the Tree, to cause a continual growth in thickness. Fig. 2. G G G are a sort of Vessels which run Horizontal, beginning from the Pith of the Tree, but afterwards in great numbers taking their rise from the ascending Vessels. These Vessels appeared to me like dark streaks running crooked, and winding for the most part along the sides of the great Vessels. To observe these Vessels better, I caused the Wood to be cut in length in such manner that I came to divide the said Vessels a-cross very neatly. The same Vessels lye not above 5, 6, or 7
one

one above another, as they are here drawn between the up-
rising Vessels P Q O N. Fig. 4.

The second sort of Horizontal Vessels which lye in great numbers together, but in some places much more then others, are described Fig. 2. A B or C D: but when we cut the Wood in pieces longways, and thereby cut crosse these Vessels, then they appear our naked Eye as Fig. 5. R S. I have also drawn the same in many places at their length, with crooked Partitions, ^d which I judged to be Valves tho I have not been able to see them always so clearly as they are here exprest, but after I had found them some times, I concluded them to be generally so, both because I have seen them in Elm Wood, as also that I concluded without these Valves it were impossible the Tree should increase in thickness, because of the force that is necessary not only to ^e separate the Bark in the Spring from the wood, and keep it loose; but also to cleave and open the Bark all the time the Tree is growing; and thereby make place for its increase in thickness. Now if there were none of these Valves, then the Sap which was impelled by the heat of the Sun against the Bark, with the setting of the Sun (when I conceive the Sap ceases ^f to rise) would fall back again, and cause a labour in vain. In this small piece of Wood Fig. 4. T, V. (described by a magnifying Glass which augmenteth more then that by which the Uprising Vessels are drawn, that so the Vessels might appear more distinct) there are more then 2000 Vessels, each of which if it be allowed but $\frac{1}{2}$ of a Grain of force in the protruding

^d Sig. Malpighi. and Dr. Grew do both make these Partitions to be the Terminations of the bladders of which these Radiated parts consist, and not Valves. See the foremention'd Anatomy of Tr, Fig. 21. p. 21, 22. and Anat. of Roots, Tab. 7.

^e Dr. Grew thinks that the Bark is never separated from the wood. See Anat. of Tr. p. 52. &c.

^f Yet Vines and other Plants do bleed day and night.

its moisture, the force, all these Horizontal Vessels together must use towards the separation of the Bark from the Wood, will appear by this Calculation. Suppose then that Fig. 4. is $\frac{1}{16}$ of a Square Inch, and that in the whole piece are but 2000 Vessels, which make in a Square Inch 1400000 Vessels, that is 2-0000 Grains; this number divided by 10240, which is as many Grains as make a Pound, makes full 34 Pound, for the force which the Vessels in so small a piece of Wood come to exercise upon the Bark. When we examin the Bark thus torn from the Tree, we shall see the Uprising Vessels of which the Bark is for the most part constituted, and which from the first formation went up streight, and were placed regularly one by another, now in some places lye wide from one another, and in some closer, but this is not the Natural Constitution.

We know that there is great difference between Oak wood growing in high and low ground; or in cold, or warmer Countries; or of slow or quick growth: but this piece here drawn was a close good wood, and therewith of a full growth. When we cut any wood through, in its length, so that the cutting of the Knife cleaves the Horizontal Vessels asunder, it will seldom happen that the cutting of the Knife will handsomely cleave the vessels. But the Knife for the most part cuts the Rising and Horizontal vessels aslant; which causeth a false appearance, as if the Rising and Horizontal vessels were knit one into another, as Linnen or Basket-work: and to cut the Horizontal vessels cross, we must conceive the first time, that the Knife is gone through the Center of the Tree or Bough, and the second time that the Knife is drawn parallel with the first cut.

In Figure Sixth ABCD is represented a piece of Elm-wood (which to the naked Eye is as big as Figure E) and is what this Tree increased in one year in thickness.

A D and **B C** show the ceasing of the growth in the years end.

The small Rising vessels which lye together between the great vessels, are in this wood smaller then in Oak, and therewithal each Pipe consists of a thicker Film, then the Pipes of the Oak do.

A B and **C D** shew the Horizontal vessels at full length.

Fig. 7 F F F F shew the Horizontal Vessels cut a-cross ; those of them which lye but few together, I conceive to be Vessels lately proceeding out of the riseing Vessels : whereas on the contrary the other Vessels which lye many together, have subsisted many years, and are as many in number as they ever will be. **G G G G.** shew the small riseing Vessels at length.

H H Shews one of the great riseing Vessels in length, cut cross in the midst ; yet when we observe the same more exactly we see that they consist of very thin Films, beset with Helical Threds, exhibiting obscure spots upon the hoops or bows as **Fig. 3.**

Among these Trees there are several which upon tapping yield a Sap. This Sap I have several times, and several years observed, and taken notice in it of divers small Animals, which I could not imagine should have come out of the Wood, but rather that they might have come from rain-water or Dew.

Figure 8. A B C D. is a piece of Beech (as big as **Fig. F** to the naked Eye) the thickness of one years growth, wherein one may plainly see at **A D** or **B C** the beginning and end of the years growth. In this Wood there are represented two sorts of riseing vessels. *viz.* greater and smaller ; and I imagine that there are also two sorts of Horizontal Vessels, which are very small : one of which *viz.* **E E E** lyes but 1, 2, 3, or more together, as **Fig. 9.** which shows those Vessels cut through and marked by **H H.**

the

The 2d sort, which lye far asunder, as in proportion D from G and are marked out in their length by D C: these vessels are likewise very small, and accordingly the rising Vessels lye very close one to another, they are likewise cut asunder overthwart as Fig. 9, I. I.

K K K. Are the great rising vessels cut asunder longwaies: which I generally observed to be beset with small parts, that through a Common Magnifying Glass seemed to be Globules.

Fig. 10. A B C D. Represents a little piece of Willow wood, as big to the naked Eye as Fig. F. the same consists also of two sorts of rising Vessels, small and great, the great ones beset with little parts, seeming Globules. In the same I saw bending lines which heretofore I imagined to have been valves, as is represented Fig. 11, in one of the same rising vessels marked by G. These small rising Vessels have exceeding thin Films, which twas impossible for me to delineate with red Chalk, so finely as was requisite.

In this Wood I saw but one sort of Horizontal vessels marked Fig 10 by E E E. These vessels are but few in comparison of the Horizontal vessels, which I hitherto have observed in other Woods. The same are not far extended in length, and for breadth they lie single.

Fig. 11. H H H. the same vessels cut a-thwart are represented between the rising vessels being at their length.

In one of the great rising vessels fig. 11. G G. I likewise shewed that they are beset with little parts seeming Globules, but they are exceeding small.

Fig. 12. Is a piece of Alder-wood the breadth whereof is about the bigness of the bristle of a Hog, to the naked Eye. It consists likewise of two sorts of rising vessels; whereof the smallest consists of exceeding thin films, and the greatest sort of films beset with little parts extremely small, to which you can give no other names than Globules.

Between

Between A B. and C D. is the increase of the Tree in a years time.

E E E E. Are the vessels which run Horizontal.

Fig. 13. F F Are the great rising vessels cut through longwaies.

H H Are the small rising vessels.

G G The Horizontal vessels cut a-cross

Fig. 14. A B C D E F is a little piece of black *Mauritius* Ebony Wood, exhibited by a Microscope magnifying more then any of the former; because these vessels could not well be observed by the Ordinary Glasses, and this little piece of wood wherein are shewn about 1100 rising vessels, is no bigger than to be covered by an Ordinary grain of Sand.

I purposed at first to have drawn this Wood more at large, having intended to have shewn its decrease in the latter end of the year, and increase at the beginning of the year or Spring: But in my attempting I found that my labor would be frustrated, because that wood grows in a Climate where it increases always: for the Island *Mauritius* lies in a few degrees North of the Tropick of *Capricorn*. In this wood I am perswaded there are four sorts of rising vessels.

G G G Are great rising Vessels, whereof some appear to have contained a fluid matter, which in drying seems to have closed them together in several places, as fig. 15, II where one of the Vessels is plainly exhibited at length.

Fig. 16 Is likewise one of the greater vessels (magnified more by a yet greater Glass) which was much more perspicuous than the former; beset also with exceeding small parts

The 2^d sort of rising vessels which are placed generally between the Horizontal vessels A B C and H H are likewise in many places partly filled with black matter.

The 3^d sort of rising vessels which follow the Circumference of the Tree are B and C D E

E e

The

The 4th sort of rising vessels are those which go Checker-wise between the great rising vessels. These vessels are of a firm Wood, in proportion to the vessels of other Wood; for the small round which is placed in the white is only the openness of every rising vessel; and the white wherein the round is placed is the wood that formeth the vessel; and these vessels are so close and firm joyned to one another, that they seem to be but one; as if we should imagine that small holes were bored regularly in firm wood.

Fig. 15. K K K. are the Horizontal vessels cut cross through: of which I have represented two in their length, fig. 14. A B C. and H H.

Fig 15. L L are small rising vessels in their length cut one from another.

Fig. 17. Is a piece of Palm wood, drawn by the same Magnifying Glass that the *Mauritius* Ebony wood was. This Wood tho I examined a great deal of it, I could find little difference in the several parts; and therefore I have here contented my self with describing a smaller portion. It consists (for ought I can find) of two sorts of ascending vessels viz. Great vessels, and smaller vessels lying amongst the great. The great Vessels consist also of Skins being beset with small rising particles, as in fig. 18. where the Vessels are opened longwaies, and represented by E E E E.

The small Vessels have their cavities very like those of the small vessels in *Mauritius* Ebony Wood; and are described cut the longwaies in fig. 18. F F.

A B or C D. are the Horizontal Vessels which in their length shew themselves thus; but being cut overthwart are as G G in fig. 18.

Fig. 19. A B C D E F. Is a description of a very small piece of Straw cut cross, in which the part of the Circumference (A F) may be discerned how great it is.

A B E F Is the rind of the Straw, which to outward Appear

pearance is smooth and shining : tho for the most part 'tis made of extream small vessels, and of some greater, which I have represented as near as possible.

G G G G Are the *Vessels* of which the innermost parts of the Straw are made ; these vessels are 4, 5, and 6. sided according as they come to fit themselves.

H H H Are vessels which run in between the forementioned vessels and are beset round with small vessels. In these vessels I have seen the sap sink down suddenly at the time of the growing of the Straw, when at the same time I saw the Sap rise up in the vessels **G G**, which Sap was made most of Globules ; and when the Globules came to pass the valves where the vessels were narrowest ; these Globules then changed into the form of Cones, till they obtained a larger Room, and then they retook their former Globousness

Fig. 20. are the rising vessels described in their length, being the same with these represented fig. 19. **G G**.

I I I I. Are the places where these Valves are, and where the vessels are narrowest.

I have in mine of the 23 of *April* mentioned the great number of small creatures in the Melt of a *Cod* or *Pike*. I have prosecuted my speculation, and observed the Melt of a *Perch* ; also of a *Breem* and a *Vooren*, as also of a *Tench*, at the time when they cast their Seed : and have seen in the same an incredible number of small Animals, as I mentioned in my former. But because the forementioned fishes do not shoot their Seed at once ; I have not been able to compare them together that I might if possible have discovered whether there were any difference in their shape or bigness : but so far as I could remember, I conceive there was no difference. And if any persons are inclined to make the same observations, they must be sure to take the time when the said fishes shoot their Seed : for at that time the Melt, which is ready to come out, is thin and watery ; and

then these animals in it live longest, and move very briskly; whereas on the contrary the Melt being not full ripe, we must with force press it out of the Fish, and then it is difficult to see these Animalcules alive.

A Theory of the Variation of the Magnetical COMPASS, by Mr. Ed. Halley Fellow of the R. S.

THE Variation of the Compass (by which I mean the deflection of the Magnetical Needle from the true Meridian) is of that great concernment in the Art of Navigation: that the neglect thereof, does little less than render useless one of the noblest Inventions mankind ever yet attained to. And for this cause all Ships of Consequence (especially those bound beyond the Equator) carry with them Instruments on purpose to observe this Variation: that so the course steered by the Compass, may be reduced to the true course in respect of the Meridian.

Now altho the great utility that a perfect knowledge of the Theory of the Magnetical direction would afford to mankind in general, and especially to those concerned in Sea affairs, seem a sufficient incitement to all Philosophical and Mathematical heads, to take under serious consideration the several *Phænomena*, and to endeavour to reconcile them
by

Fig: 1.

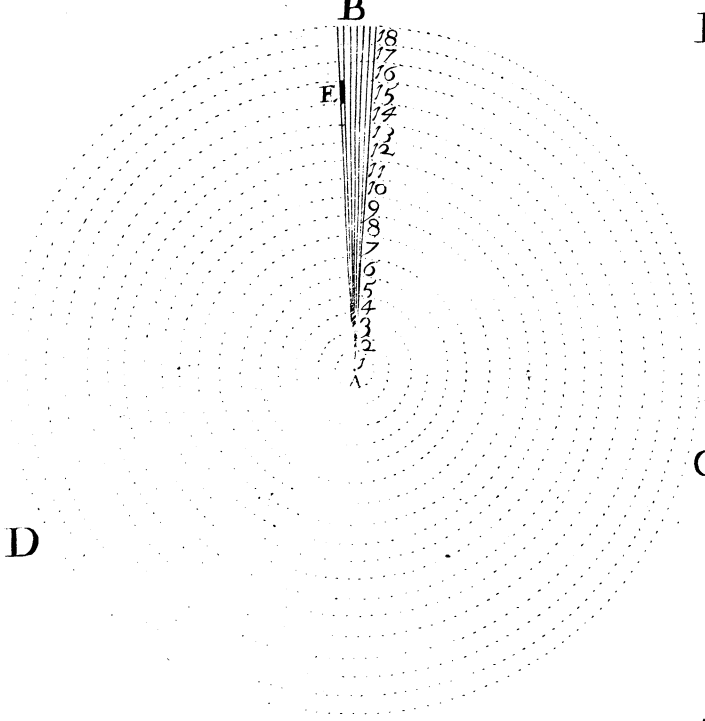


Fig: 2.

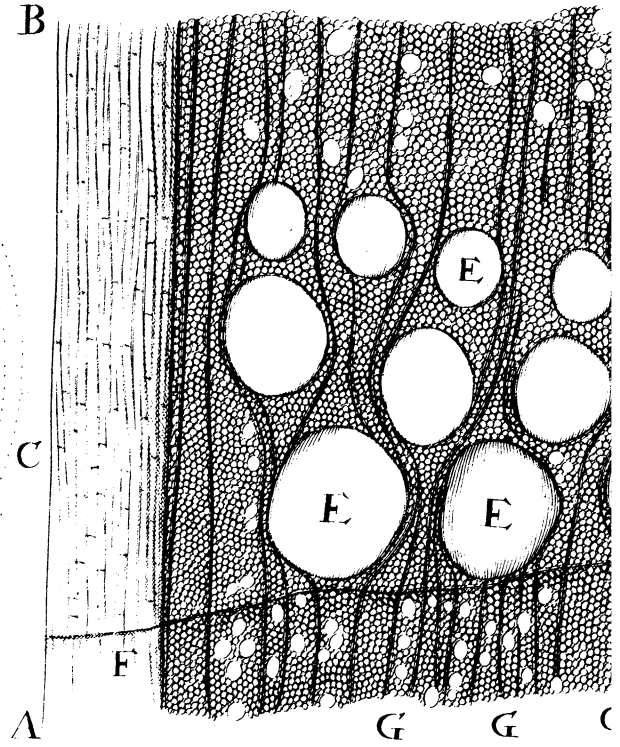


Fig: 8.

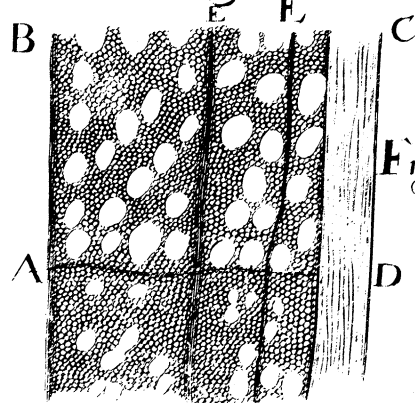


Fig: 11.



Fig: 12.

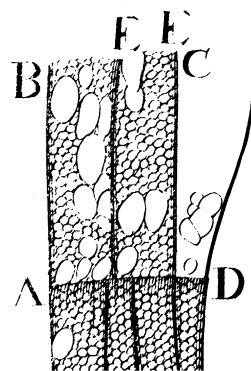


Fig: 13.

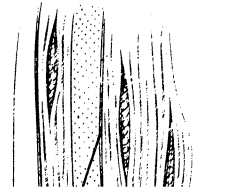


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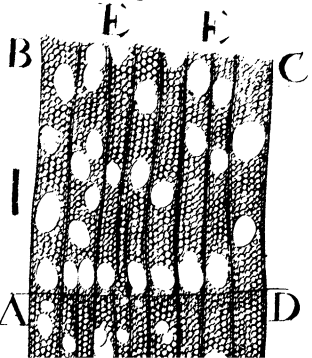


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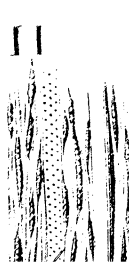
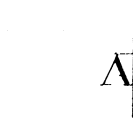
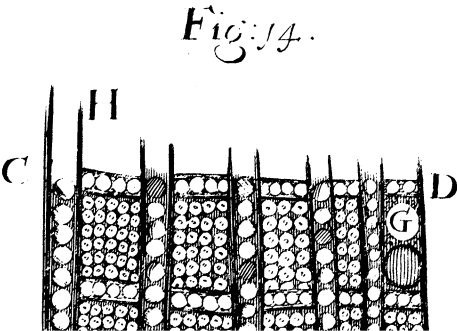
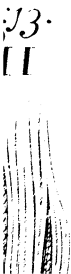
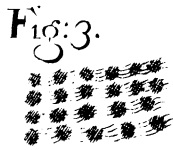
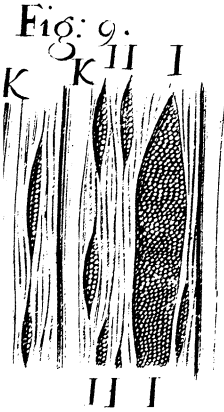
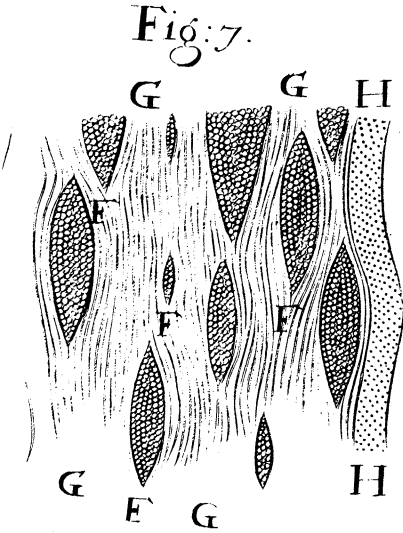
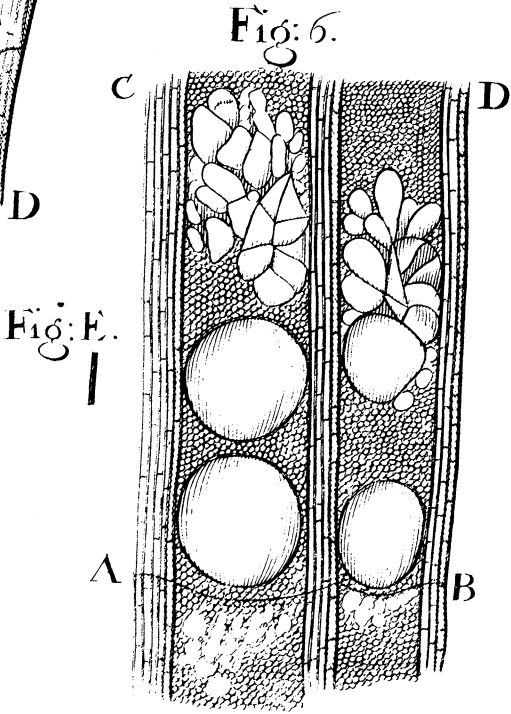
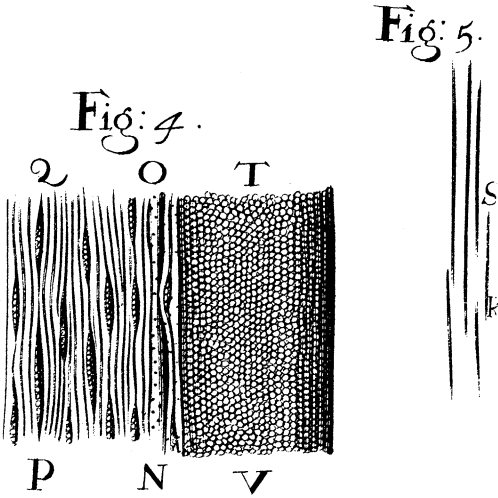
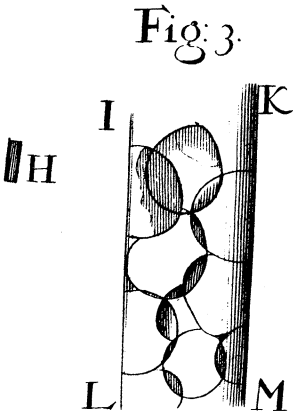
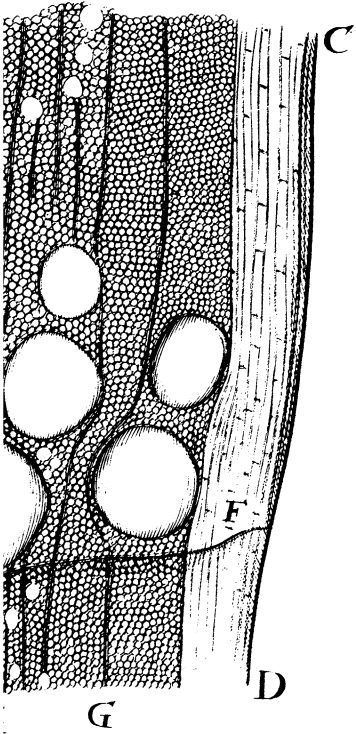


Fig: 11.





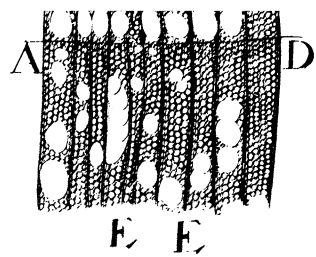


Fig: 16.



Fig: 17.

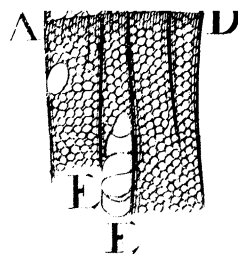
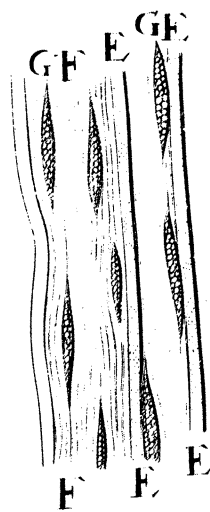
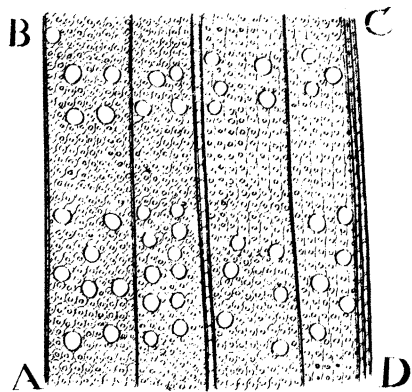
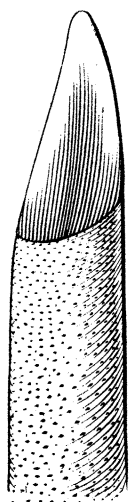
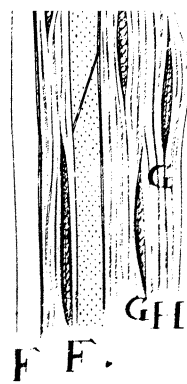


Fig: 18.



S: sculp.

B
A

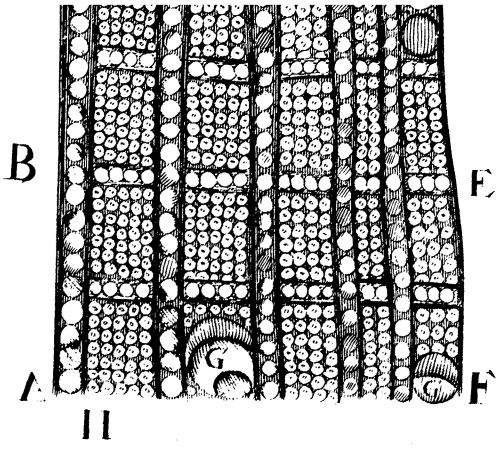


Fig. 19.

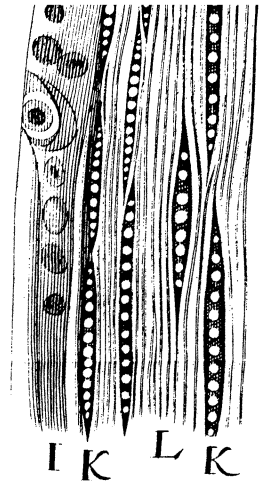
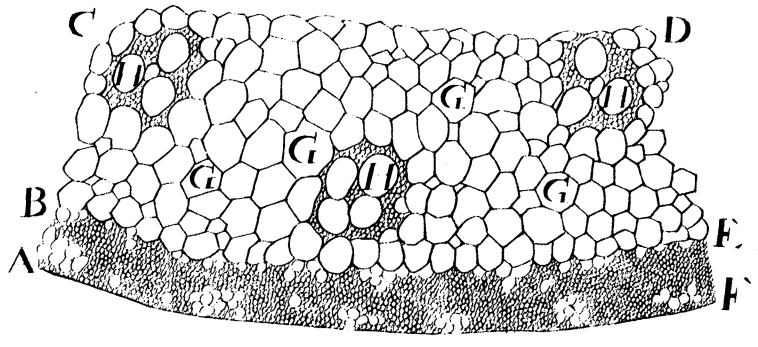


Fig. 20.

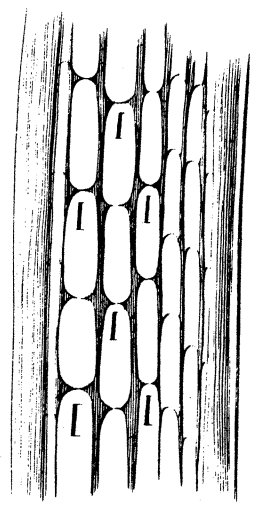


Fig. 1.



Fig. 2.

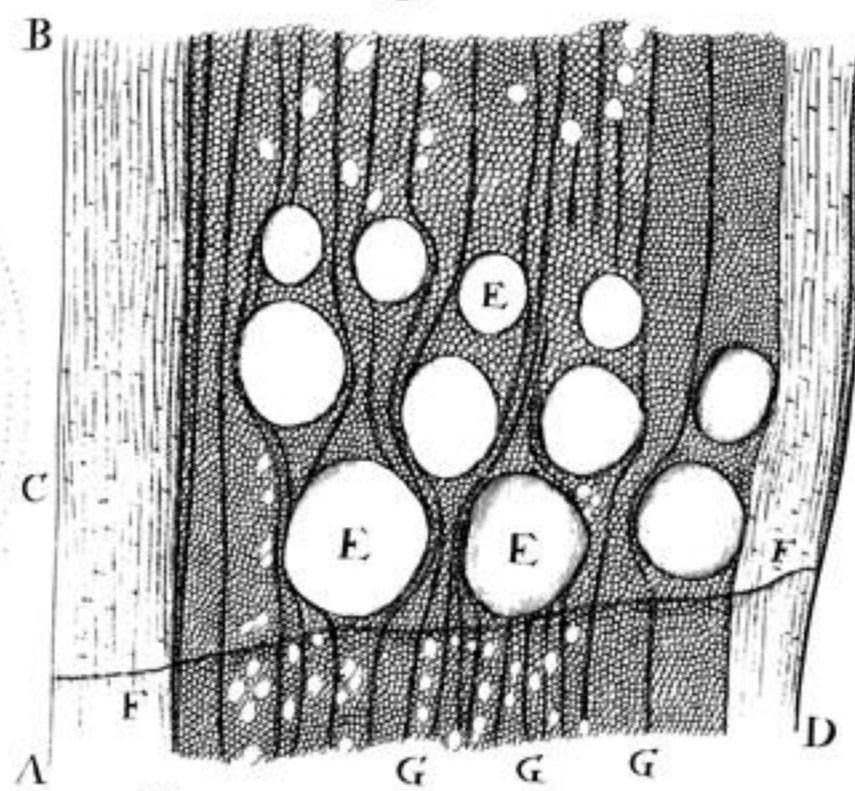


Fig. 3.

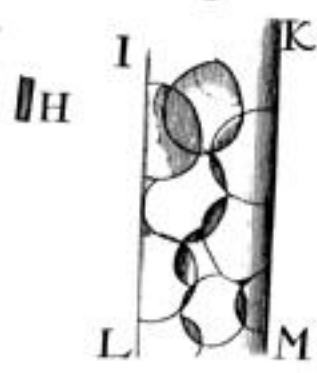


Fig. 4.

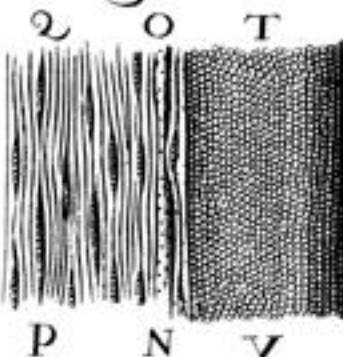


Fig. 5.



Fig. 6.

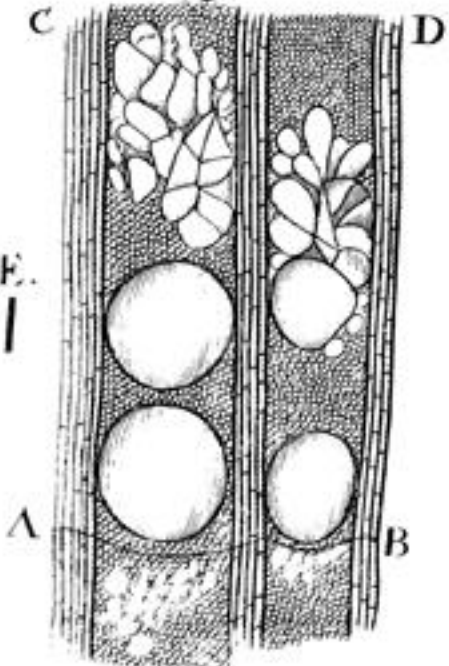


Fig. 7.

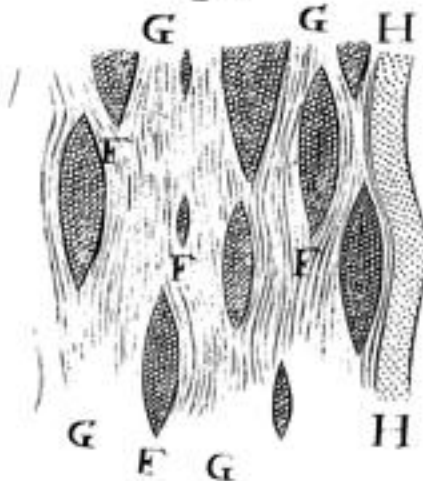


Fig. 8.

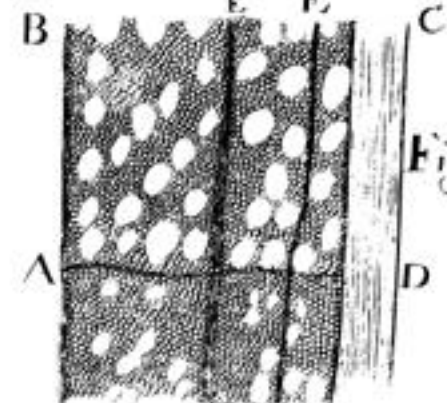


Fig. 9.



Fig. 10.



Fig. 11.



Fig. 12.

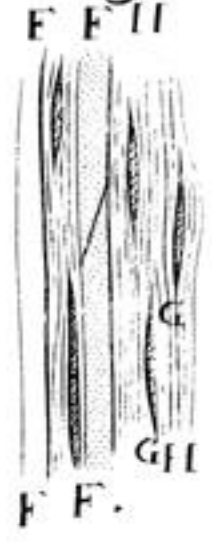


Fig. 13.

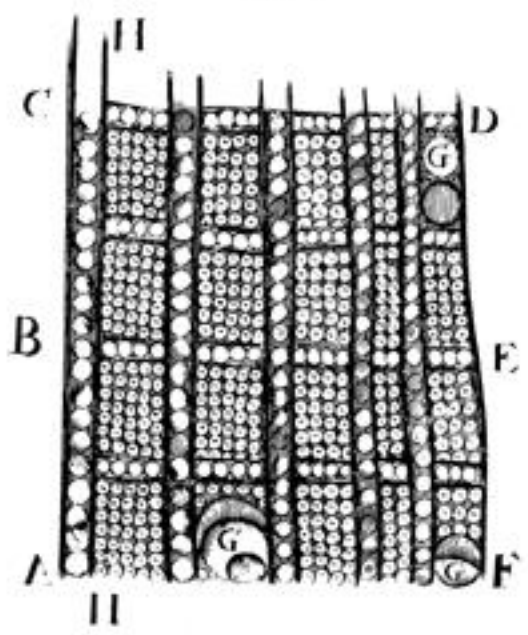


Fig. 14.

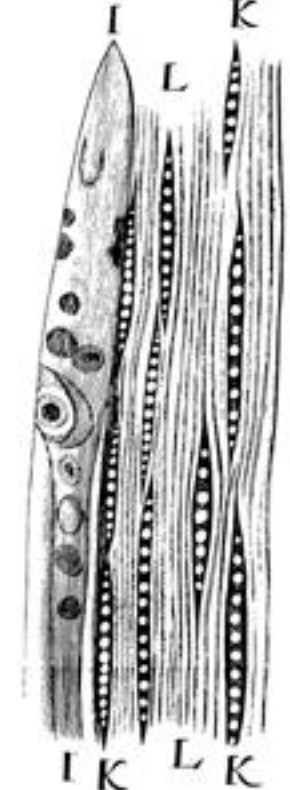


Fig. 15.

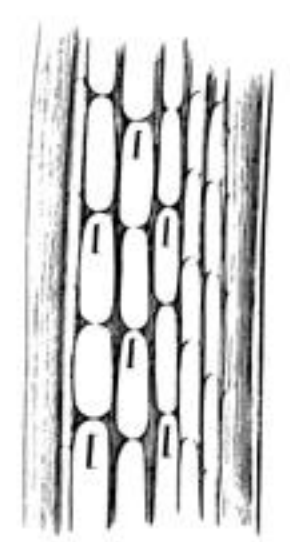


Fig. 16.

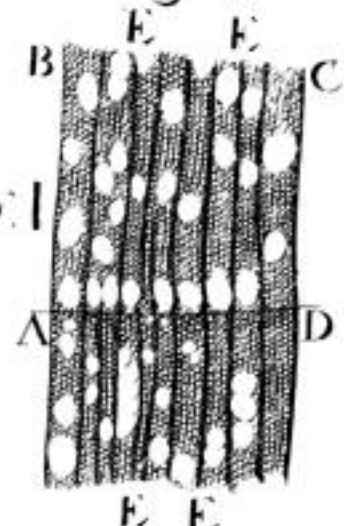


Fig. 17.

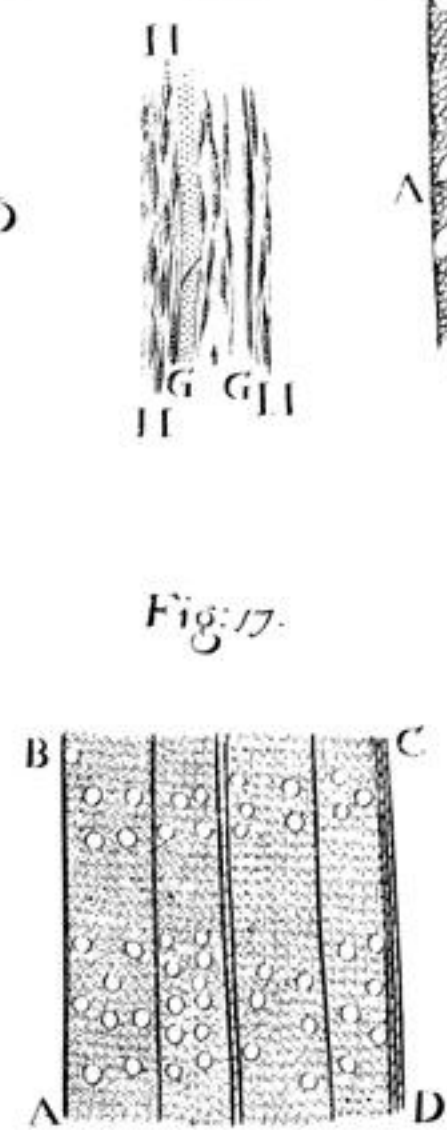


Fig. 18.



Fig. 19.

